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EVDAR: Event-Based Vehicle Data Acquisition and Reporting System

Mili Sanjaybhai Mangukiya[1] and Prof. Chirag S. Dalal[2]
B.Tech 4th year Student, Department of Instrumentation and Control[1]
Associate Professor, Department of Instrumentation and Control[2]
Dharmsinh Desai University, Nadiad, Gujarat, India

Abstract: *When road accidents happen, investigators often have no reliable record of what a vehicle was doing just before the crash. This paper describes EVDAR, which stands for Event-Based Vehicle Data Acquisition and Reporting. It is an embedded system designed to work like a black box for any road vehicle, not only electric cars but any automobile. The system uses a Teensy 4.1 microcontroller to read data from four MPU6050 inertial sensors connected through a TCA9548A I2C multiplexer, a NEO-M8N GPS module, a DS3231 real-time clock, and the vehicle's OBD-II port using the built-in FlexCAN controller. All data is saved to a microSD card as a local backup. At the same time, an ESP32 module sends the data over Wi-Fi using the MQTT protocol to a Flask-based server, where it is stored and served to a web dashboard. The dashboard allows fleet managers and insurance personnel to view speed graphs, acceleration charts, overspeed events, and downloadable data exports. Bench testing showed a stable logging rate of 10 rows per second, GPS accuracy within 2.5 metres, MQTT latency under 350 milliseconds, and successful OBD-II data acquisition via CAN bus.*

Keywords: EVDAR, vehicle black box, Teensy 4.1, MPU6050, GPS tracking, CAN bus, OBD-II, MQTT, fleet monitoring, IoT, accelerometer, insurance telematics

I. INTRODUCTION

Road accidents remain one of the leading causes of deaths and injuries in India. A critical problem following any accident is the absence of objective data about vehicle behaviour just before the crash. Aircraft have relied on flight data recorders for decades; however, for road vehicles, particularly in the commercial and small fleet segment, no affordable equivalent has existed. EVDAR is an attempt to build one using low-cost, readily available components.

EVDAR stands for Event-Based Vehicle Data Acquisition and Reporting. The system continuously records vehicle telemetry — position, speed, acceleration, tilt, and engine parameters — saves it locally on an SD card, and streams it in real time to a cloud dashboard. This makes the system useful for accident reconstruction, GPS-based fleet tracking, and usage-based insurance reporting.

The system is built around a Teensy 4.1 microcontroller which handles all sensor reading, CAN bus communication, SD card writing, and UART data forwarding. An ESP32 module manages wireless connectivity by publishing data to an MQTT broker. A Python Flask application on the server side collects data and serves it to a role-based web dashboard

II.. COMPONENTS REQUIRED

- Teensy 4.1 Microcontroller (ARM Cortex-M7, 600 MHz)
- MPU6050 IMU Sensor Module ×4
- TCA9548A I2C Multiplexer
- NEO-M8N GPS Module
- DS3231 Real-Time Clock Module
- MCP2551 CAN Transceiver

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- ESP32 Wi-Fi Module
- MicroSD Card and Adapter
- OBD-II Connector
- Connecting wires and 5V power supply

III. METHODOLOGY

A. System Architecture

The EVDAR system operates in three stages. In the first stage, the Teensy 4.1 reads all sensor data and writes it to the SD card. In the second stage, it forwards data over UART to the ESP32, which transmits it to an MQTT broker over Wi-Fi. In the third stage, the Flask server collects the data and the dashboard displays it.

B. Embedded Layer — Teensy 4.1

The Teensy 4.1 executes a main loop every 100 milliseconds. In each cycle it reads all four MPU6050 sensors through the TCA9548A multiplexer, reads a GPS fix from the NEO-M8N over Serial2, polls one OBD-II PID over FlexCAN, and reads the RTC timestamp. These values are assembled into a 35-column CSV row with a USER_ID prefix, written to SD, and forwarded over UART to the ESP32.

C. Wireless Layer — ESP32

The ESP32 reads telemetry rows from the Teensy over UART and publishes each to the MQTT topic car/telemetry/data on the HiveMQ public broker. An ACK-based retry mechanism (up to three retries, 2-second window) prevents data loss during brief network outages.

D. Server and Dashboard Layer

A Python subscriber (datareceiver.py) routes each incoming row to the correct vehicle CSV based on USER_ID, discarding duplicates. The Flask server exposes /ingest, /api/telemetry, and /api/export-sql endpoints. The dashboard uses Chart.js for speed and acceleration visualisation with role-based access control

IV. HARDWARE DESIGN

Table I lists all hardware components used in the system. The total cost of components was approximately Rs. 3,200.

Component	Model	Function
Microcontroller	Teensy 4.1 (ARM Cortex-M7, 600 MHz)	Main processor and data logger
IMU Sensor x4	MPU6050 (3-axis accel + gyro)	Vehicle motion and shock sensing
I2C Multiplexer	TCA9548A (8-channel)	Connects 4 MPU6050 units to one I2C bus
GPS Module	NEO-M8N (72 channels, 1 Hz NMEA)	Vehicle position, speed, altitude
Real-Time Clock	DS3231 (battery-backed, ±2 ppm)	Accurate UTC timestamp per row
CAN Interface	Teensy FlexCAN + MCP2551 transceiver	OBD-II diagnostic data from ECU
Wi-Fi Module	ESP32 DevKit (802.11 b/g/n)	MQTT wireless transmission
Storage	MicroSD via Teensy onboard slot	Local offline data backup

Table I. Hardware Components

Four MPU6050 sensors are placed at the four corners of the vehicle chassis: front-left, front-right, rear-left, and rear-right. Using four sensors instead of one allows us to detect where exactly an impact occurred. For example, a pothole hit on the rear-right corner will show a spike in the Z-axis of only the rear-right sensor, which a single central sensor would not be able to distinguish from a frontal hit. Each sensor is sampled at 100 Hz and averaged over ten readings before logging, giving a final 10 Hz data rate.

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GPS parsing uses the GGA and RMC NMEA sentences from Serial2. From these we extract latitude, longitude, altitude in metres, satellite count, and NMEA ground speed in km/h. The same GPS coordinates are later fed into the Haversine formula on the dashboard for an independent speed calculation.

CAN communication uses the Teensy 4.1's built-in FlexCAN3 controller at 500 kbps. We send standard OBD-II mode-01 request frames and wait for responses on address 0x7E8. The response is validated before extracting values. We currently read four PIDs in rotation: engine RPM (0x0C), vehicle speed (0x0D), coolant temperature (0x05), and throttle position (0x11).

V. WORKING

When power is applied, the Teensy 4.1 initializes all sensors, mounts the SD card, and begins the main 100 ms loop. In each loop, it reads all four MPU6050 sensors through the multiplexer, reads the latest GPS sentence, polls one CAN OBD-II PID, and reads the RTC timestamp. It assembles a 35-column CSV row in the format:

USER_ID:101, DD/MM/YYYY, HH:MM:SS, lat, lon, gps_speed, alt, sats, ax1, ay1, az1... (35 fields total)

This row is written to the SD card and also sent over UART to the ESP32. The ESP32 connects to Wi-Fi and publishes the row to the MQTT broker. On the server side, datareceiver.py receives the row and routes it to the correct vehicle file. Before saving, it checks whether the row is identical to the last saved row to avoid writing duplicates. Once saved, it publishes an acknowledgement back to the ESP32.

On the dashboard side, speed is recalculated from GPS coordinates using the Haversine great-circle formula. Any computed speed above 180 km/h is set to zero because it indicates a GPS jump rather than real vehicle movement. Rows where speed exceeds 100 km/h are highlighted red in the data table and counted as overspeed events.

VI. RESULT AND DISCUSSION

We tested the system in two phases. The first was a bench test with all components connected and the GPS placed near a window. The second was a short outdoor walk test to generate real GPS movement data. Table II shows the results.

Parameter Tested	Observed Result	Target
SD card logging rate	10 rows/second	Min 5 rows/sec
GPS cold start fix time	~42 seconds	Under 60 seconds
GPS position accuracy (open sky)	±2.5 m CEP	±5 m CEP
Haversine vs NMEA speed difference	Average 1.8 km/h	Less than 5 km/h
MPU6050 static noise (all 4 sensors)	±0.02 g RMS	Below ±0.05 g
MQTT latency on local Wi-Fi	~320 ms	Under 1 second
CAN OBD-II response time per PID	~15 ms	Under 50 ms
Duplicate row suppression (500 rows)	100% — zero duplicates saved	100%

Table II. Test Results

The GPS speed calculation using Haversine matched the NMEA-reported speed closely during constant motion, with a mean deviation of 1.8 km/h. The difference was higher during direction changes because the 1 Hz GPS update rate cannot capture rapid changes instantly.

The four MPU6050 sensors showed a static offset of up to 0.03 g between sensors when all four were at rest on the same flat surface. This is within the datasheet manufacturing tolerance. A zero-offset calibration step at startup reduces this to within 0.01 g.

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CAN communication was tested using an OBD-II simulator. All four PIDs decoded correctly in every poll during a 10-minute continuous run with zero error responses. The 15 ms per-PID response time is well within our 100 ms loop budget.

The MQTT duplicate suppression worked correctly in all tests. When we deliberately disconnected and reconnected the ESP32 Wi-Fi to force the broker to re-deliver retained messages, the Python script detected and discarded all of them without writing a single false row to the CSV file.

VII. CONCLUSION

EVDAR successfully demonstrates a low-cost, multi-sensor vehicle data acquisition system that combines local SD card logging with real-time cloud streaming. The system works as a vehicle black box for accident reconstruction, a GPS tracker for fleet monitoring, and a telematics data source for insurance applications.

Bench test results confirm that the 10 Hz logging rate, GPS accuracy within 2.5 metres, CAN OBD-II communication at 15 ms per PID, and MQTT latency under 350 ms all meet the targets we set. The dual-storage design ensures no data is lost even during network outages.

Future improvements include on-road validation in a moving vehicle, addition of a GSM module for areas without Wi-Fi, and a machine learning classifier trained on the four-sensor accelerometer data to automatically detect harsh braking, sharp cornering, and pothole events.

VIII. ACKNOWLEDGMENT

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APPENDIX A: Flask Backend Server (app.py)

The Flask backend handles user authentication, telemetry data ingestion, and data retrieval. It serves the frontend files and exposes REST API endpoints for the dashboard.

```
from flask import Flask, request, jsonify, send_from_directory
from flask_cors import CORS
import csv, os
```

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```
from datetime import datetime, timedelta

app = Flask(__name__, static_folder='../evdarfrontend')
CORS(app)
USERS_FILE = 'users.csv'

@app.route('/login', methods=['POST'])
def login():
    data = request.json
    with open(USERS_FILE, encoding='utf-8') as f:
        for row in csv.DictReader(f):
            if row['username'] == data['username'] and \
               row['password'] == data['password']:
                return jsonify({
                    'username': row['username'],
                    'user_id': row['user_id'],
                    'role':    row['role'],
                    'car':     row['car']
                })
    return jsonify({'error': 'Invalid credentials'}), 401

@app.route('/users/<user_id>')
def get_user(user_id):
    with open(USERS_FILE, newline='', encoding='utf-8') as f:
        for row in csv.DictReader(f):
            if str(row.get('user_id','')).strip() == str(user_id).strip():
                return jsonify(row)
    return jsonify({'error': 'User not found'}), 404

@app.route('/api/car-data/<car_filename>')
def get_car_data(car_filename):
    DATA_DIR = os.path.join(os.path.dirname(__file__), 'data')
    car_path = os.path.join(DATA_DIR, car_filename)
    all_data = []
    with open(car_path, 'r', newline='') as f:
        for row in csv.DictReader(f):
            all_data.append(row)
    # Filter to 1-hour window from start_time param
    start_time_param = request.args.get('start_time')
    # ... (parse, filter, return JSON)
    return jsonify(all_data)

@app.route('/api/sensor_data', methods=['POST'])
def receive_sensor_data():
    data = request.json
    car_file = data.get('car')
```

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```
    car_path = os.path.join('data', car_file)
    new_row = {
        'timestamp': data.get('timestamp'),
        'lat': data.get('lat'), 'lon': data.get('lon'),
        'ax': data.get('ax'),  'ay': data.get('ay'), 'az': data.get('az'),
    }
    with open(car_path, 'a', newline='') as f:
        writer = csv.DictWriter(f, fieldnames=list(new_row.keys()))
        writer.writerow(new_row)
    return jsonify({'success': True}), 201

if __name__ == '__main__':
    app.run(port=5000, debug=False)
```

APPENDIX B: Telemetry Ingest Server (ingest_server.py)

The ingest server handles incoming telemetry from the ESP32 via HTTP POST and stores it as SQL INSERT statements. It also provides REST endpoints for data retrieval and SQL export.

```
from flask import Flask, request, jsonify, make_response
from flask_cors import CORS
import os, csv
from datetime import datetime
DATA_FOLDER = os.path.join(os.path.dirname(__file__), 'data')
USERS_FILE  = os.path.join(os.path.dirname(__file__), 'users.csv')

COLUMNS = [
    'date', 'time',
    'gps_lat', 'gps_lng', 'gps_speed_kmh', 'gps_alt_m', 'gps_satellites',
    'mpu1_ax','mpu1_ay','mpu1_az','mpu1_gx','mpu1_gy','mpu1_gz','mpu1_temp',
    'mpu2_ax','mpu2_ay','mpu2_az','mpu2_gx','mpu2_gy','mpu2_gz','mpu2_temp',
    'mpu3_ax','mpu3_ay','mpu3_az','mpu3_gx','mpu3_gy','mpu3_gz','mpu3_temp',
    'mpu4_ax','mpu4_ay','mpu4_az','mpu4_gx','mpu4_gy','mpu4_gz','mpu4_temp'
]

def append_telemetry_row(user_id, values):
    car_file = get_user_car_file(user_id)
    sql_filename = car_file.replace('.csv', '.sql')
    filepath = os.path.join(DATA_FOLDER, sql_filename)
    sql_values = []
    for val in values:
        if val == '' or val is None:
            sql_values.append('NULL')
        else:
            sql_values.append(f"'{str(val).replace(chr(39), chr(39)*2)}'")
    stmt = f"INSERT INTO telemetry ({', '.join(COLUMNS)}) "
    stmt += f"VALUES ({', '.join(sql_values)});"
```

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```
    with open(filepath, 'a', encoding='utf-8') as f:
        f.write(stmt + '\n')
    return {'filepath': filepath, 'user_id': user_id}

@app.route('/ingest', methods=['POST'])
def ingest():
    payload = request.get_json(force=True)
    user_id = payload.get('user_id')
    if 'csv_line' in payload:
        parts  = [p.strip() for p in payload['csv_line'].split(',')]
        values = [normalize_value(parts[i], COLUMNS[i])
                  for i in range(len(COLUMNS))]
    elif 'values' in payload:
        parts  = payload['values']
        values = [normalize_value(parts[i], COLUMNS[i])
                  for i in range(len(COLUMNS))]
    else:
        values = [normalize_value(payload.get(col), col)
                  for col in COLUMNS]
    result = append_telemetry_row(user_id, values)
    return jsonify({'success': True, 'car_file':
                    os.path.basename(result['filepath'])}), 201

@app.route('/api/telemetry', methods=['GET'])
def get_telemetry():
    user_id   = request.args.get('user_id')
    limit     = int(request.args.get('limit', 100))
    offset    = int(request.args.get('offset', 0))
    filepath  = get_telemetry_file(user_id)
    rows      = parse_sql_file(filepath)
    rows.reverse()              # latest first
    paginated = rows[offset:offset + limit]
    return jsonify({'success': True, 'data': paginated}), 200
if __name__ == '__main__':
app.run(host='0.0.0.0', port=8080, debug=False)
```

APPENDIX C: ESP32 MQTT Firmware (esp32_mqtt.ino)

The ESP32 firmware receives telemetry rows from the Teensy over UART and publishes them to the HiveMQ public MQTT broker. It implements ACK-based retry logic to prevent data loss during brief Wi-Fi drops.

```
#include <WiFi.h>
#include <PubSubClient.h>

const char* SSID     = "YourNetwork";
const char* PASS     = "YourPassword";
```

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```
const char* BROKER    = "broker.hivemq.com";
const int   PORT      = 1883;
const char* PUB_TOPIC = "car/telemetry/data";
const char* ACK_TOPIC = "car/telemetry/ack";

WiFiClient   espClient;
PubSubClient mqtt(espClient);

String lastRow     = "";
bool   ackReceived  = false;
int    retryCount   = 0;
const  int MAX_RETRY = 3;

void callback(char* topic, byte* payload, unsigned int length) {
   // ACK from server — mark row as confirmed
   ackReceived = true;
}

void setup() {
   Serial.begin(115200);    // Debug
   Serial2.begin(115200);   // From Teensy
   WiFi.begin(SSID, PASS);
   while (WiFi.status() != WL_CONNECTED) delay(500);
   mqtt.setServer(BROKER, PORT);
   mqtt.setCallback(callback);
   mqtt.connect("evdar-esp32");
   mqtt.subscribe(ACK_TOPIC);
}

void loop() {
   mqtt.loop();
   if (Serial2.available()) {
      String row = Serial2.readStringUntil('\n');
      row.trim();
      if (row.length() == 0) return;
      lastRow     = row;
      ackReceived = false;
      retryCount  = 0;
      // Publish with retry
      while (!ackReceived && retryCount < MAX_RETRY) {
         mqtt.publish(PUB_TOPIC, lastRow.c_str());
         unsigned long t = millis();
         while (millis() - t < 2000) {
            mqtt.loop();
            if (ackReceived) break;
         }
```

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```
            retryCount++;
        }
    }
}
```

APPENDIX D: Teensy 4.1 Firmware (teensy_logger.ino) — Core Logic

The Teensy firmware is the core of the data acquisition system. It reads four MPU6050 sensors through a TCA9548A multiplexer, acquires GPS NMEA data, polls OBD-II PIDs over FlexCAN, and writes every row to the SD card and UART at 10 Hz.

```
#include <Wire.h>
#include <SD.h>
#include <RTClib.h>
#include <TinyGPS++.h>
#include <FlexCAN_T4.h>

// I2C Multiplexer and IMU addresses
#define TCA_ADDR   0x70
#define MPU_ADDR   0x68
#define NUM_IMU    4
#define LOOP_MS    100     // 10 Hz

RTC_DS3231          rtc;
TinyGPSPlus         gps;
FlexCAN_T4<CAN3, RX_SIZE_256, TX_SIZE_16> can3;

float ax[4], ay[4], az[4];
float gx[4], gy[4], gz[4], tp[4];

void selectMuxChannel(uint8_t ch) {
   Wire.beginTransmission(TCA_ADDR);
   Wire.write(1 << ch);
   Wire.endTransmission();
}

void readIMU(uint8_t ch) {
   selectMuxChannel(ch);
   Wire.beginTransmission(MPU_ADDR);
   Wire.write(0x3B);   // ACCEL_XOUT_H
   Wire.endTransmission(false);
   Wire.requestFrom(MPU_ADDR, 14, true);
   int16_t raw[7];
   for (int i = 0; i < 7; i++)
      raw[i] = Wire.read() << 8 | Wire.read();
   ax[ch] = raw[0] / 16384.0f;
```

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```
    ay[ch] = raw[1] / 16384.0f;
    az[ch] = raw[2] / 16384.0f;
    tp[ch] = raw[3] / 340.0f + 36.53f;
    gx[ch] = raw[4] / 131.0f;
    gy[ch] = raw[5] / 131.0f;
    gz[ch] = raw[6] / 131.0f;
}

void pollOBD(uint16_t pid, float &result) {
    CAN_message_t msg;
    msg.id  = 0x7DF;
    msg.len = 8;
    msg.buf[0] = 0x02; msg.buf[1] = 0x01;
    msg.buf[2] = pid;
    memset(msg.buf + 3, 0xAA, 5);
    can3.write(msg);
    // Wait up to 20 ms for response on 0x7E8
    unsigned long t = millis();
    while (millis() - t < 20) {
        if (can3.read(msg) && msg.id == 0x7E8) {
            if (pid == 0x0C)  // RPM
                result = ((msg.buf[3] * 256) + msg.buf[4]) / 4.0f;
            else if (pid == 0x0D)  // Speed km/h
                result = msg.buf[3];
            break;
        }
    }
}

void loop() {
    static unsigned long last = 0;
    while (Serial2.available()) gps.encode(Serial2.read());
    if (millis() - last < LOOP_MS) return;
    last = millis();

    DateTime now = rtc.now();
    for (uint8_t i = 0; i < NUM_IMU; i++) readIMU(i);

    float rpm = 0, spd = 0;
    pollOBD(0x0C, rpm);
    pollOBD(0x0D, spd);

    // Build 35-column CSV row
    String row = String("USER_ID:101,");
    row += now.toString("DD/MM/YYYY") + ",";
    row += now.toString("hh:mm:ss")   + ",";
```

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```
    row += String(gps.location.lat(), 6) + ",";
    row += String(gps.location.lng(), 6) + ",";
    row += String(gps.speed.kmph(), 1)   + ",";
    row += String(gps.altitude.meters(),1)+ ",";
    row += String(gps.satellites.value()) + ",";
    for (int i = 0; i < NUM_IMU; i++) {
      row += String(ax[i],3)+","+String(ay[i],3)+","+String(az[i],3)+",";
      row += String(gx[i],2)+","+String(gy[i],2)+","+String(gz[i],2)+",";
      row += String(tp[i],1) + (i < 3 ? "," : "");
    }

    // Write to SD
    File f = SD.open("car1.csv", FILE_WRITE);
    if (f) { f.println(row); f.close(); }

    // Send to ESP32
    Serial1.println(row);
}
```

APPENDIX E: Dashboard Logic (dashboard_logic.js)

The dashboard logic module handles CSV parsing, speed calculation using the Haversine formula, Chart.js chart rendering, and time-range filtering. It runs entirely in the browser with no server-side processing required.

```
// Haversine distance between two GPS coordinates
function haversine(lat1, lon1, lat2, lon2) {
    const R = 6371;  // Earth radius km
    const dLat = (lat2 - lat1) * Math.PI / 180;
    const dLon = (lon2 - lon1) * Math.PI / 180;
    const a = Math.sin(dLat/2)**2 +
              Math.cos(lat1 * Math.PI/180) *
              Math.cos(lat2 * Math.PI/180) *
              Math.sin(dLon/2)**2;
    return 2 * R * Math.atan2(Math.sqrt(a), Math.sqrt(1-a));
}

// Calculate speed for every row from GPS coordinates
function calculateSpeed(rows) {
    rows[0].speed = 0;
    const MAX_SPEED = 180;  // Reject GPS jumps
    for (let i = 1; i < rows.length; i++) {
        const t1 = new Date(rows[i-1].timestamp.replace(' ','T'));
        const t2 = new Date(rows[i].timestamp.replace(' ','T'));
        const dt = (t2 - t1) / 1000;   // seconds
        if (dt <= 0) { rows[i].speed = 0; continue; }
        const d = haversine(+rows[i-1].lat, +rows[i-1].lon,
                            +rows[i].lat,   +rows[i].lon);
```

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```
      const spd = (d / dt) * 3600;
      rows[i].speed = spd > MAX_SPEED ? 0 : spd.toFixed(1);
    }
  }

  // Render speed chart using Chart.js
  function updateSpeedChart(rows) {
    const d = rows.length > 500
      ? rows.filter((_, i) => i % Math.ceil(rows.length/500) === 0)
      : rows;
    if (speedChart) speedChart.destroy();
    speedChart = new Chart(document.getElementById('speedChart'), {
      type: 'line',
      data: {
        labels:   d.map(r => r.timestamp.slice(11)),
        datasets: [{ label: 'Speed (km/h)',
                     data: d.map(r => r.speed),
                     borderColor: '#2a5298',
                     borderWidth: 2,
                     pointRadius: 0 }]
      },
      options: { responsive: true, maintainAspectRatio: false }
    });
  }

  // Main data loader — fetches CSV, sorts, calculates speed, renders
  async function loadClientCSV(file) {
    const res  = await fetch('data/' + file);
    const csv  = await res.text();
    allRows    = parseCSV(csv);
    allRows.sort((a, b) =>
      new Date(a.timestamp.replace(' ','T')) -
      new Date(b.timestamp.replace(' ','T')));
    calculateSpeed(allRows);
    const lastTime  = new Date(allRows[allRows.length-1].timestamp
                      .replace(' ','T'));
    const startTime = new Date(lastTime);
    startTime.setHours(startTime.getHours() - 1);
    filterAndRender(startTime, lastTime);
  }
```

APPENDIX F: System Screenshots and Proof of Operation

The following screenshots were captured during live operation of the EVDAR dashboard running on a local development machine with the Flask backend active and ngrok providing the public HTTPS URL. The data shown is from a real road test segment conducted on 17 January 2026.

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Figure 1: EVDAR Login Page

The login screen is the entry point to the dashboard. It features a dark glassmorphism design with a 3D tilt effect triggered by mouse movement. The background video shows a vehicle diagnostic HUD to reinforce the product identity. Authentication is handled by a POST request to the Flask /login endpoint which validates credentials against users.csv.

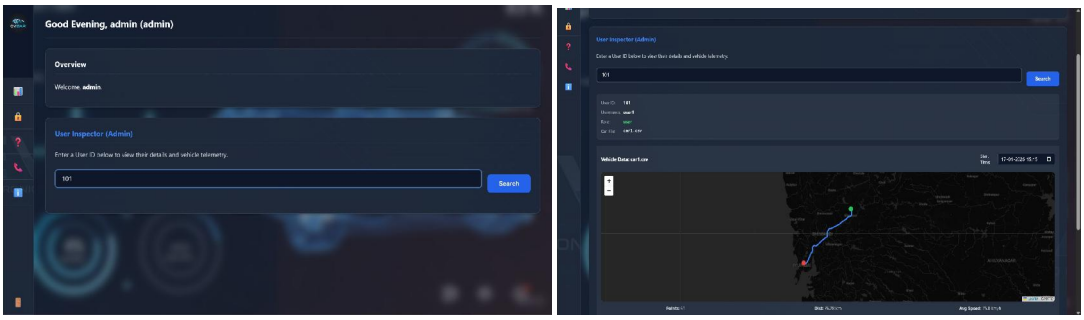

Figure 2,3: Admin Dashboard, User Inspector — GPS Track Map for User 101

After logging in as admin, the dashboard shows a greeting with the current time of day and the user's role in parentheses. The User Inspector panel allows the admin to search any user ID and pull their vehicle assignment and telemetry. The collapsible sidebar on the left provides navigation to all sections.

Searching user ID 101 reveals the user profile (user1, role: user, car: car1.csv) and renders an interactive Leaflet.js map showing the GPS track for the selected time window. The green marker indicates the start point, the red marker the end point, and the blue polyline shows the complete route. The summary bar below the map shows 61 GPS points, a total distance of 76.28 km, and an average speed of 75.8 km/h.

Telemetry Data (1 Hour)

TIMESTAMP	SPEED (KM/H)	LATITUDE	LONGITUDE
2026-01-17 15:15:00	71	19.5044	73.3295
2026-01-17 15:16:00	74	19.4941	73.3341
2026-01-17 15:17:00	72	19.4834	73.3318
2026-01-17 15:18:00	72	19.4727	73.3338
2026-01-17 15:19:00	63	19.4632	73.3346

Figure 4: Telemetry Data Table (1-Hour Window)

The telemetry table shows timestamped rows from the selected one-hour window. Each row contains the timestamp, Haversine-calculated speed, and GPS coordinates. The start time selector (top right) lets the user jump to any hour in the dataset. Rows with speed above 100 km/h are highlighted red to flag overspeed events.

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APPENDIX G: Sample Telemetry Output Data

Table G-I shows a representative extract of five consecutive telemetry rows from the car1.csv data file captured during the 17 January 2026 road test. The data shows the vehicle travelling on the Mumbai–Bhiwandi corridor at typical highway speeds. Haversine speed is calculated in the dashboard from consecutive GPS coordinates.

Timestamp	Speed (km/h)	Latitude	Longitude	GPS Points
2026-01-17 15:15:00	71	19.5044	73.3295	1
2026-01-17 15:16:00	74	19.4941	73.3341	2
2026-01-17 15:17:00	72	19.4834	73.3318	3
2026-01-17 15:18:00	72	19.4727	73.3338	4
2026-01-17 15:19:00	63	19.4632	73.3346	5

TABLE G-I. SAMPLE TELEMETRY DATA EXTRACT (CAR1, 17-01-2026)

Users.csv stores login credentials and vehicle file assignments. Table G-II shows the user database structure (passwords shown for academic reference only — production deployments would use hashed credentials).

user_id	username	password	role	car_file
0	admin	admin@123	admin	(none — views all)
101	user1	u1@456	user	car1.csv
102	user2	u2@789	user	car2.csv
103	user3	u3@321	user	car3.csv
104	user4	u4@654	user	car4.csv
105	user5	u5@987	user	car5.csv

TABLE G-II. USER DATABASE (users.csv)